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Review of the New World species of *Salina* (Collembola: Paronellidae) with bidentate mucro, including a key to all New World members of *Salina*

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Abstract

The taxonomic status of the four New World species of *Salina* MacGillivray with bidentate mucro is uncertain. The first two species to be described, *S. bidentata* (Handschin) and *S. wolcotti* Folsom, are so poorly described by modern standards that it is unclear if they represent distinct species or the same, colour-pattern variable forms. This contribution presents additions to the description of *S. beta* Christiansen & Bellinger based on the holotype, a redescription of *S. bidentata* and *S. wolcotti* based on freshly collected material from Costa Rica, Puerto Rico and Florida, USA, and description of a new species, *S. thibaudi*, from Costa Rica and Guadaloupe. Based on analysis of chaetotaxic patterns it is concluded that *S. bidentata* and *S. wolcotti* are distinct species, although it remains unclear if *S. ventricolor* Gruia, from Cuba is distinct from *S. wolcotti*. The discovery in Costa Rica and Guadaloupe of *S. thibaudi*, showing a distinct chaetotaxy, but with colour pattern identical to that illustrated in the original description of *S. wolcotti*, suggests that records of *S. wolcotti* outside Puerto Rico require verification. A key for the identification of all species of *Salina* reported from the Americas is provided.

Key words: Greater Antilles, Lesser Antilles, Central America, taxonomy, chaetotaxy, *Salina thibaudi* **n. sp**., *Salina wolcotti*, *Salina bidentata, Salina beta, Salina ventricolor*

Resumen

La validez taxonómica de las cuatro especies americanas del género *Salina* con mucrón bidentado es incierta. Las descripciones de las dos primeras especies descubiertas, *S. bidentata* y *S. wolcotti*, son muy incompletas con relación a los modelos contemporáneos de las descripciones y hay incertidumbre de si éstas representan formas diferentes o simplemente variedades con diferentes patrones de coloración. Con el fin de aclarar esta incertidumbre, aquí se presentan adiciones a la descripción de *S. beta* basadas en el holotipo, además se presentan redescripciones de *S. bidentata* y *S. wolcotti* usando material recientemente colectado en Costa Rica, Puerto Rico y Florida, USA, y se describe una nueva especie, *S. thibaudi*, de Guadalupe y Costa Rica. El análisis de la quetotaxia tergal indica que *S. bidentata* y *S. wolcotti* son especies distintas y fácilmente separables, aunque aún no queda claro si *S. ventricolor*, descrita de Cuba, es diferente de *S. wolcotti*. El descubrimiento de *S. thibaudi*, con un patrón de coloración idéntico al originalmente descrito para *S. wolcotti* sugiere que los registros de *S. wolcotti* fuera de la isla de Puerto Rico requieren ser verificados usando quetotaxia. Finalmente, se incluye una clave para la identificación de todas las especies de *Salina* reportadas del Continente Americano

Introduction

Salina MacGillivray is a medium-sized (Bellinger *et al*. 1996–2009) genus of Paronellidae with 63 species distributed principally across India, tropical East Asia and the Americas. In the New World, the genus is represented by 12 to 13 named species found from central Michigan in North America, through Central America, the Caribbean and south to Argentina. Members of *Salina* show a very homogeneous morphology

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that makes separation of species difficult. Traditionally, species have been diagnosed based on colour pattern, mucronal and unguicular shape, number of ungual teeth and dorsal chaetotaxy.

Mitra (1993) and Yoshi (1981, 1983) subdivided the genus using chaetotaxy, but each author used a different set of criteria and, as a result, the groups they proposed partially overlap. In the case of Mitra's system, the criteria used to determine alliance to either group (*celebensis* or *indica*) was based on states observed in East Asian species and cannot unambiguously be applied to the American species. In addition, the dorsal head chaetotaxy, which is one of the criteria used by Mitra to group species, is not known for most New World species. Yoshi's (1981, 1983) system is simpler and divides *Salina* into four groups according to the number of macrosetae on the first and second abdominal segments. Following Yoshi, the ten New World species for which the chaetotaxy is known, fall in three groups: *beta* (2 species), *celebensis* (7 species) and *borneesis* (1 species). However, these subdivisions have not been adopted by authors publishing on the New World species. Instead, New World forms have been treated as comprising two groups distinguished by mucronal shape (e.g., Mari Mutt 1987b). Nine of the thirteen named New World species have a square (somewhat longer than wider in most species) or a truncate mucro with 3–4 teeth pointing posteriorly (Figs. 6, 7); the other four species have rectangular mucrones in which at least the two largest teeth point dorsally (Fig. 8a).

Taxonomically, the group with rectangular mucrones (henceforth *beta* group) is the most problematic. Of the four species in the *beta* group (*S. bidentata* (Handschin), 1927, *S. wolcotti*, Folsom, 1927, *S. ventricolor* Gruia, 1983 and *S. beta* Christiansen & Bellinger, 1980), the full dorsal chaetotaxy is known only for *S. ventricolor*, whereas only the chaetotaxy of the metathorax and the first two abdominal segments has been described for *S. beta*. Colour pattern will unambiguously identify only *S. beta* and, apparently, patterned specimens of *S. wolcotti*. The original descriptions of *S. bidentata* and *S. wolcotti* are incomplete by modern standards, since they do not include chaetotaxic characters, and the only differences between these species appear to be the presence of two unpaired ungual teeth and the distinct colour pattern of some individuals of *S. wolcotti* (Fig. 12). Because light coloured individuals of *S. wolcotti* display the minimalist pattern described for *S. ventricolor* (Fig. 11) and *S. bidentata*, it is possible that these three names represent the same, colour-pattern, variable species. *Salina bidentata* was described from "San Jose", Costa Rica and has not been reported since the original description (see remarks following the description of the *beta* group).

Salina wolcotti was described from numerous individuals collected throughout the island of Puerto Rico where it was said to be present at all elevations and in many different plant hosts (Folsom 1927). In addition to the bidentate rectangular mucro, the species was characterised by a unique colour pattern formed by black "amoeboid" spots with light centres (Fig. 12). Subsequently, the species was reported from Costa Rica, Jamaica, Venezuela, Mexico and Florida (Mari Mutt & Bellinger 1990, 1996; Wray 1959; Escher & Lounibus 1993), making this the most often cited member of the genus in the New World. Unfortunately, the true identity of this species remains elusive since its chaetotaxy is unknown. In Puerto Rico individuals with the amoeboid colour pattern have not been observed since at least 1962 and the last known individual (before the present report) with bidentate mucro was collected in 1973 in the west-central mountain region of the island. All *Salina* recorded from Puerto Rico since 1974 fit the description of *S. tristani* Denis, 1931, a species with a square mucro (Mari Mutt 1982, 1986, 1987b).

During a recent phylogeographic study of the *Salina* populations in Puerto Rico, it was noted that a sample of individuals collected in the Toro Negro Commonwealth Forest in the central mountain region of the island carried a mitochondrial lineage deeply divergent in relation to all other island populations (F. Soto-Adames unpublished data). Slide preparations of individuals from this population showed that, despite having a colour pattern indistinguishable from *S. tristani*, the mucro was bidentate, of the type described for *S. wolcotti*. Since Folsom (1927) indicated that some individuals of *S. wolcotti* did not show the amoeboid colour pattern it is logical to assume that the material from Toro Negro represents a remnant population of *S. wolcotti*.

In order to clarify the relationship between these forms, redescriptions of *S. wolcotti* and *S. bidentata* are presented. The redescription of *S. wolcotti* is based on one syntype deposited at the Illinois Natural History

Survey and on additional material collected recently in Puerto Rico. The repository of the type material for *S. bidentata* is unknown and the species is redescribed using material collected in Costa Rica and Florida (USA). Additions to the description *S. beta* are presented based on the holotype, and a new species, *S. thibaudi* n. sp., is described from Guadeloupe and Costa Rica. A preliminary identification key and diagnostic table to all species of *Salina* reported from the Americas are also provided.

Results and discussion

The general morphology of members of the *beta* group considered below is almost identical and in order to avoid redundancy in the narrative a general description is provided as part of the definition of the group. The individual species descriptions are limited to unique or variable conditions, and diagnostic differences are listed in Table 1.

In the descriptions that follow, when the number of setae on a field varies, the first number represents the mode, while the range across all individuals in which the character was observed follows in parenthesis. Antennal, thoracic and abdominal are abbreviated as Ant., Th. and Abd., respectively. All the material examined was collected by the author, unless otherwise stated.

The holotype of *S. thibaudi* **n. sp.** is deposited in the collection of the National Museum of Natural History in Paris. Paratypes of the new species, and material of all other species remain in the collection of the Illinois Natural History Survey, Champaign, Illinois, USA.

Salina beta species group

Fourth antennal segment with apical papilla. Eyes (Fig. 2) A, B, E, F subequal, eyes C, D smaller, eyes G and H smallest; with 1 macro- and 2 microsetae in eyepatch (Fig.1). Ant. 1 with variable number of dorsal macrosetae according to the species. Dorsal head macrochaetotaxy as in Fig. 2; macrosetae marked with arrows are smaller than others in some individuals of S. *wolcotti* and *S. bidentata*; these macrosetae also apparently absent in *S. ventricolor*. Prelabral setae always ciliate and either 2 or 4, according to species; labrum with 5, 5, 4 smooth setae, internal pair on distal row enlarged, weakly spine-like (Fig. 3); labral papillae 2+2 smooth mounds. Subapical seta of outer maxillary lobe acuminate, smooth and shorter than apical seta; sublobular plate with three seta-like processes. Labial palps with five proximal setae; hypostomal seta (H of Fjellberg 1999) spine-like, h1 and h2 apically curved. Labial palp papillae A and C without guard setae; papillae B and D, with 5 and 4 guards, respectively; papilla E (Fig. 4) with two guards (apparently e1 and e2), lateral appendage blunt and not reaching tip of papilla. Labial triangle setae as MEL1–3, A1–4, all smooth. Most setae along cephalic groove (column CG) long acuminate and ciliate, in some species short smooth setae present between ciliate setae (Fig. 5), number of setae variable between and within species, individuals often with asymmetric number of setae; medial postlabial column (PLM) always with 2 long, ciliate acuminate setae, posterior seta inserted between setae CG1–2; external postlabial column (PLE) with variable number of setae, but column not well organized, often making it difficult to determine if a particular setae should be counted as part of column or not. Tergal macrochaetotaxy of Th. 2–Abd. 2 variable; Abd. 3 with 2 macrosetae typical for genus. Abd. 4 with at least 8 inner and 8–9 outer macrosetae, 2–3 marginal mesosetae, and 0–7 posterior microsetae arranged as in Fig. 9, individuals of some species with supplementary macrosetae often asymmetrically distributed (e.g., Fig. 32). Abd. 4 with 2 bothriotricha, presumably homologous to those in all Entomobryoidea (Fig. 9 setae a and b), and three other bothriotricha-like setae distributed as in Fig. 9. Bothriotricha-like setae shorter than normal bothriotricha (Fig. 10) and without differentiated sockets, but inserted in the same relative position in all individuals examined. Inner face of femoral base of all legs with 4 pegs. Foot complex typical for genus: tenent hair thick, ciliate and strongly spatulate; unguiculus strongly truncate; unguis with short outer and lateral teeth, small paired inner teeth and

1–2 inconspicuous distal unpaired teeth. Anterior face of collophore with 3–4 distal macrosetae and variable number of microsetae according to species; number of lateral setae variable; posterior face with 1–6 paired and 0–3 unpaired microsetae. Distal manubrial plate with 3+3 ciliate setae, without pseudopores. Distal dental vesicle elongate, subequal to mucro (Fig. 8a); mucro with 2 large upturned teeth, and 1 short, dorso-basal denticle, additional supplementary teeth present or absent according to species.

Remarks: The diagnostic character of the *beta* species group is the presence of a rectangular mucro, with the two largest teeth pointing dorsally instead of posteriorly and a short dorsal tooth basal to the large subapical tooth. Currently the *beta* group comprises four named species and one new species described here. An undescribed species from Panama, with two inner macrosetae on Abd. 2, was represented by a single individual, insufficient material for a proper description. *Salina montana* (Imms, 1912) and *S. choudhurii* Mitra, 1973 from India may have tridentate mucrones somewhat similar to members of the *beta* group although it is difficult to judge from Imms' (1912) and Mitra's (1973) drawings. Both Indian species have reduced chaetotaxy on Th. 2–3, with pattern similar to that in the *beta* group, but the chaetotaxy of Abd. 3, and Abd. 4 (at least in *choudhurii*) are different to that in New World species. A more detailed study of the Indian forms will be needed to decide if they are part of the *S. beta* lineage.

The four species in the genus *Pseudosalina* Mitra, 1974, are endemic to the Indian subcontinent and all have bidentate mucrones. However, in *Pseudosalina*, the mucronal structure is similar to that in species with square mucrones (cf. Figs. 6 and 8 a–b), albeit with reduced number of teeth, and not to members of the *beta* group. Many other features distinguish *Pseudosalina* from members of the *beta* group, in particular, all *Pseudosalina* have a very abundant chaetotaxy, with at least eight inner macrosetae on Abd. 2.

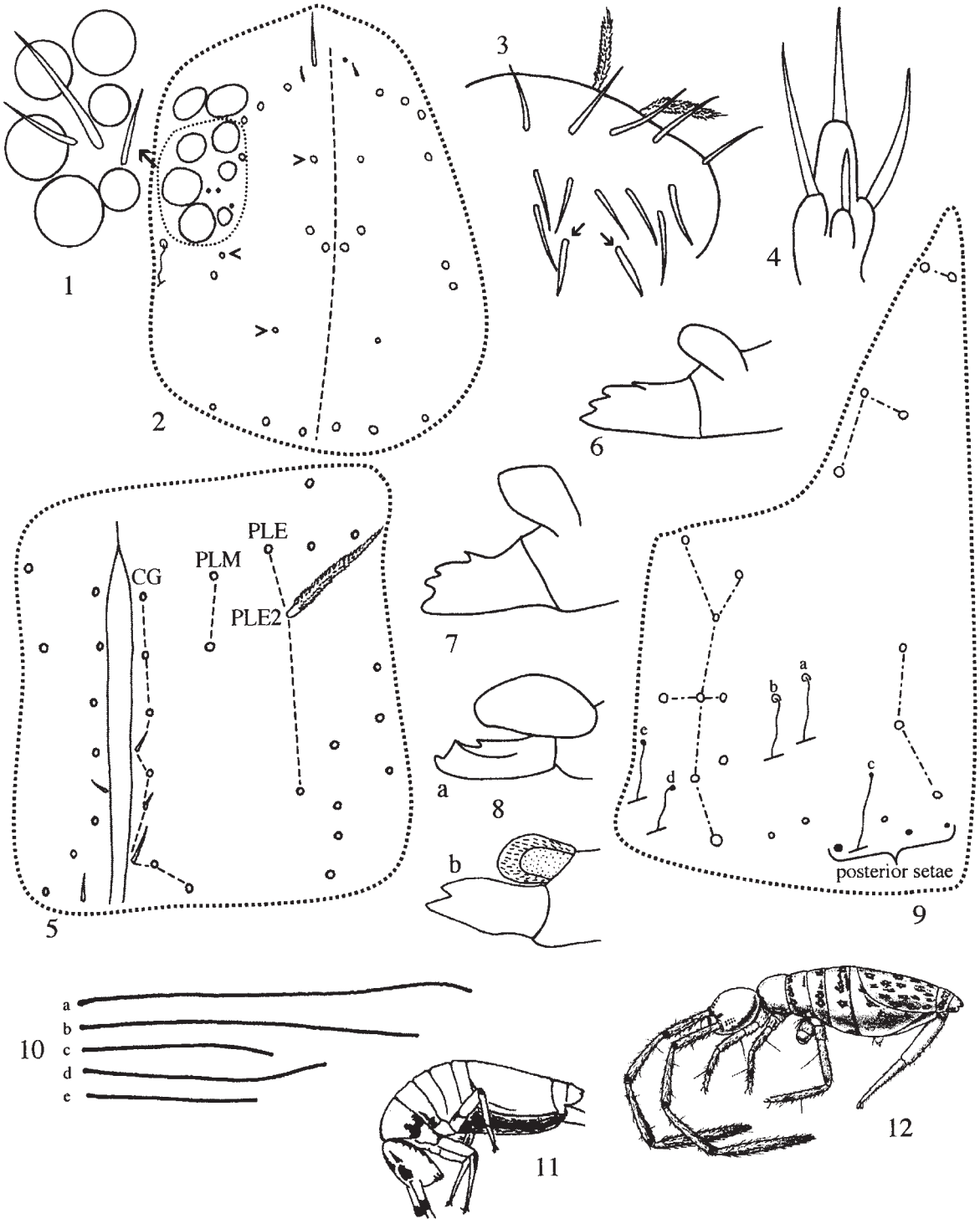
The mucronal type characteristic of the *beta* group defines a group endemic to the Americas (but see comment above). All members of the *beta* group described so far are restricted to the area delimited in the north by Southern USA (California and Florida), in the east by the Lesser Antilles and in the south by Panama. This distribution suggests that the group might have originated in Central America. However, *Salina* in general has been poorly studied and sampled in the Americas and more extensive collections in Central and South America are likely to produce new records of members of the *beta* group.

Salina wolcotti **Folsom, 1927**

Salina wolcotti Folsom, 1927: 11–12, Figs. 61–67 (Puerto Rico). Wolcott 1933: 241–242, biology (Puerto Rico). Essig 1942: 82, mention. Fennah 1947: 64, Fig. 49B, association with corn (Virgin Islands). Wolcott, 1948: 33, biology (Puerto Rico). Paclt 1956: 125, mention. Wray 1959: 68, new records (Florida, USA & Costa Rica). Guagliumi 1962: 450–452, on sugarcane (Venezuela). Martin & Gregory 1962: 297, biology (Puerto Rico). Metcalfe 1964: 24, association with sugarcane (Jamaica). Mari Mutt 1978: 5, repository of syntypes. Massoud & Thibaud, 1980: 604, mention. Mari Mutt 1982: 32, catalog of Collembola of Puerto Rico. Mari Mutt 1987b: 406, Fig. 57, taxonomic status. Escher & Lounibos, 1993: 483, association with *Pistia stratiotes* (Florida). Carithers 1997: 148, as prey of hymenopteran *Microstigmus comes* (Costa Rica). Heckman 2000: 287, Fig. 1447, key to *Salina* species. Palacios-Vargas 2000: 5, catalog (México). Palacios-Vargas 2003: 221, 223, mention (México).

Material Examined: **Puerto Rico**. Río Piedras; 23 February 1920; G. N. Wolcott, coll.; 1 slide-mounted syntype. Bayamón; 5 May (year not included); G. N. Wolcott, coll.; 1 slide-mounted syntype. Toro Negro Commonwealth Forest, N18° 10.197, W66° 29.536; beating grasses and *Impatiens* along road (PR–143) and along El Bolo trail, near forest administration building; 29 July 1999; 9 individuals on slides

Description: The condition of the slide-mounted syntype from Bayamón is such that none of the diagnostic characters are visible. The syntype from Río Piedras clearly shows 2 macrosetae on Ant. 1, 5 setae along the cephalic groove and 3, 4, 2, 2 macrosetae on Th. 2-Abd. 2. Only one prelabral seta is visible. Other potentially diagnostic characters included in Table 1 (e.g., posterior setae on Abd. 4 and posterior setae on collophore) cannot be discerned on the cleared specimen. Therefore, the description that follows is based on the specimen collected in Toro Negro.



FIGURES 1–12. 1–4 *Salina wolcotti*; 1. Detail of left eye patch; 2. Dorsal head chaetotaxy, arrow heads point at variable macrosetae (see text); 3. Prelabral and labral chaetotaxy, arrows point at spine-like setae; 4. Labial papilla E; 5. Postlabial chaetotaxy in *S. thibaudi* **n. sp**., circles represent ciliate microsetae similar to seta PLE2 illlustrated, CG= Cephalic Groove column, PLM and PLE= Post Labial Medial and External columns, respectively; 6–8. Mucro and distal dental vesicle: 6. *S. tristani*; 7. *S. banski*; 8a. *S. wolcotti*; 8b. *Pseudosalina nigrocephala* (after Mitra 1974); 9. Chaetotaxy of left side of Abd. 4 in *S. wolcotti*, large circles represent macrosetae, small circles near posterior margin are mesosetae, dots are posterior setae, dotted lines join macrosetae present in all species in the *beta* group; 10. Relative length of Abd. 4 bothriotricha and bothriotricha-like setae in *S. wolcotti*, letters refer to position in Fig. 9; 11. *S. ventricolor* colour pattern (after Gruia 1983); 12. *S. wolcotti*, colour pattern (after Folsom 1927)

Length to 1.4 mm (smallest individual= 1.1 mm; average=1.2 mm; n=8). Original colour pattern described by Folsom (1927) and shown in Fig. 12 seen only in four poorly preserved syntypes (including the slide-mounted syntype from Bayamón listed above). Freshly collected specimens background colour yellowish green, which fades to white in individuals preserved in alcohol for a long time (> ten years). Most individuals from Toro Negro and the syntype from Río Piedras without dorsal blue markings, except for a blue dot between antennae; some specimens with blue pigment distributed as described for populations of *S. tristani* from Puerto Rico (cf. Mari Mutt 1987b, Fig. 53) and *S. ventricolor* from Cuba (Fig. 11), forming a narrow band along the anterior and lateral margins of Th. 2 which extends to margins of Th. 3 or Abd. 1; blue pigment forming discreet dots distributed on postero-ventral field of head and on sternal plate of abdomen that accommodates folded furcula. Antennae amber, tip of each segment with dark blue ring; legs amber, lighter than antennae. Collophore and furcula white. Ant. 1 with 2 dorsal macrosetae (Fig. 13). Prelabral setae 2. Postlabial column CG with 5 (3–6) ciliate acuminate setae, most individuals (6 of 9) with asymmetric number of setae. Tergal chaetotaxy of Th. 2–Abd. 2 as 3(3–5), 4(2–5), 2(2–3), 2 (Figs. 14–18): Th. 2 setae numbered 3–5 in Figure 15 sometimes reduced or absent, seta 3 most often present; Th. 3 setae 2 and 5b absent in 2 and 1 individuals, respectively; Abd. 4 with 3 posterior setae (Fig. 9). Trochanteral organ with 14 (11–18) setae. Unguis with 2 distal unpaired teeth. Collophore anterior face with 3 microsetae and 3 distal macrosetae; lateral setae (Fig. 19) 10–11; posterior face with 1+1 microsetae. Proportions of dens/manubrium≈ 1, proportion of dental vesicle/mucro≈ 1. Mucro with dorso-basal denticle (Fig. 8).

Remarks: Salina wolcotti differs from *S. bidentata* in the number of dorsal macrosetae on Ant. 1, Th. 2–Abd.1 (2,3,4,2, respectively in *wolcotti*; 3,6,6,4 in *bidentata*— see Table 1 for variation range) and number of posterior setae on collophore (1+1 in *wolcotti*; 2+2 in *bidentata*). *Salina thibaudi* **n. sp**. has identical amoeboid colour pattern as illustrated for *S. wolcotti* by Folsom (1927) but it differs in practically all important chaetotaxic characters, including the number of prelabral setae (2 in *S. wolcotti*, 4 in *S. thibaudi*), the number of macrosetae on Ant. 1, Th. 2–Abd. 1, number of posterior setae on Abd. 4, and posterior setae of collophore as shown in Table 1. *Salina wolcotti* differs from *S. ventricolor* in the number of macrosetae on Th. 2 (3 in *wolcotti*, 4 in *ventricolor*), pattern of macrosetae on Th. 3 (seta 5b present and 5 absent in *wolcotti* whereas 5b absent and 5 present in *ventricolor*), number of anterior setae on collophore (6 in S. *wolcotti*; 7 in *ventricolor*) and possibly in head chaetotaxy. However, these differences may be illusory since no variation in number of setae was reported for *S. ventricolor*. With the exception of chaetotaxy on Th. 3 and anterior face of collophore, all characters described for *S. ventricolor* fall within the range of variation observed in the nine individuals of *S. wolcotti* studied from Puerto Rico. Closer examination of *S. ventricolor* populations may show this form to be a junior synonym of *S. wolcotti*. *Salina wolcotti* differs from *S. beta* in colour pattern, number of macrosetae on Th. 3–Abd. 1, and number of posterior setae on Abd. 4.

The syntypic series of *S. wolcotti* comprises specimens collected at unspecified localities in Punta Cangrejos (Carolina), Río Piedras, Bayamón, Isabela and Guánica. The syntypes deposited at the Illinois Natural History Survey were collected at Río Piedras and Bayamón, but the accompanying labels do not provide additional information about the localities. All the general localities mentioned above, except Carolina, were sampled in the late 1970 or early 1980 by Mari Mutt (1987b) or the author, but the only species collected at these localities was *S. tristani*. Based on the redescription and circumscription presented above, *S. wolcotti* appears to be endemic to Puerto Rico, with a single population remnant in the central mountain region of the island. Records of *S. wolcotti* from Florida, USA and Costa Rica (Wray 1959) are probably referable to *S. bidentata* or *S. thibaudi*, **n. sp**. (see below), but I have not studied that material. Reports of *S. wolcotti* from other localities around the Caribbean basin need to be confirmed using the characters described above.

Salina bidentata (Handschin), 1927

Crematocephalus bidentatus Handschin, 1927: 112–113, Figs. 11–12 (Costa Rica). Handschin 1928: 250, 251, 261, key and description.

Salina bidentata Denis 1931: 150, new combination, compared to *S. wolcotti*. Yosii 1956: 76, compared to *S. celebensis*. Delamare, 1951: 288, Fig. 10 a, b, illustration only (Ivory Coast). Salmon 1964: 547, synonymy. Mitra 1966: 72, compared to *S. nigrocephala*. Rapoport 1971, 112, distribution based on published records. Mitra 1974: 360, suggestion it may belong in *Pseudosalina*. Christiansen & Bellinger 1980: 1006, compared to *S. beta*. Jacquemart 1982: 19, compared to *S. panamae*. Gruia 1983: 201, compared to *S. ventricolor*. Mari Mutt 1987b: 406, possible synonym with *S. wolcotti*. Mari Mutt & Bellinger 1990: 125, records in Neotropical region. Palacios-Vargas 1992: 26, 28, mention. Christiansen & Bellinger 1998: 1128, compared to *S. beta*.

Salina bidenticulata Szeptycki, 1979: 80 (*lapsus calami*?) comment on bothriotrichal pattern.

Material Examined: **Costa Rica**. Cartago, N 9° 51.25, W 83° 50.36, elevation 1390 m; beating *Hibiscus* bushes; 30 July 2004; 2 slide-mounted individuals. As above, but on chayote (*Sechium edule*); R. Lain coll.; 1 individual on slide. **USA**. Florida, Indian River Co., Vero Beach; beating grasses along road at intersection of Fourth Street and Rd. 609; September 2001; P. Armbuster, coll.; 1 individual on slide. Broward Co., Ft. Lauderdale, N 26° 08, W 80° 17; beating grasses along road; September 2001, P. Armbuster, coll.; 1 individual on slide. Buena Vista; on lima beans; 8 December 1982; H. Weeks & D. J. Vandel; 1juvenile, slide mounted.

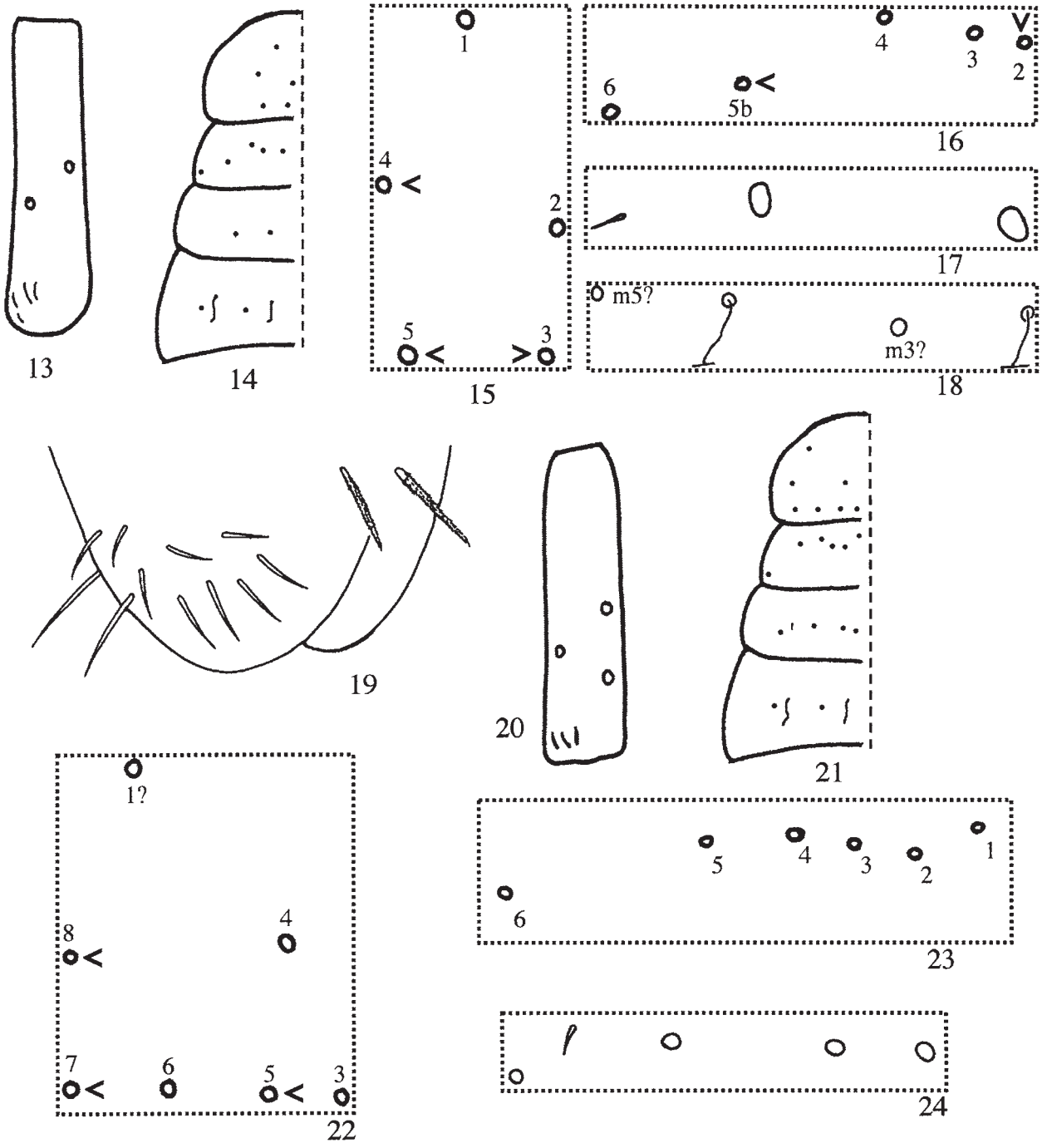
Description: Length to 1.7 mm (smallest individual= 0.8 mm; average=1.2; n=4). Body yellow, without blue pigment dorsally; ventrally with scattered blue dots concentrated on posterior part of head and abdominal sterna; antennae amber, with narrow apical blue rings on each segment; legs amber with apical rings on femora and tibia. Ant. 1 (Fig. 20) with 3 (2 in smallest individual) macrosetae. Prelabral setae 2. Postlabial columns CG with 5 normal ciliate setae (1 individual 5+6 setae). Macrochaetotaxy of Th. 2–Abd. 2 (Figs. 21–24) as 6(5–7), 6, 4(2–4), 2; Th. 2 macroseta 7 absent and 5 reduced in some individuals, socket of macroseta 8 smaller than others. Abd. 4 with 3 posterior setae. Number of setae in trochanteral organ varies with specimen size from 7 in smallest individual to 14 setae in largest individual. Claw complex normal for the genus, unguis with 1–2 distal unpaired teeth; most distal unpaired tooth always inconspicuous, sometimes apparently absent. Collophore anterior face with 4 macro- and 2 microsetae; lateral setae 11–13; posterior face with 2+2 setae (smallest individual with 1+1 setae). Proportion of dens:manubrium≈ 1.3 for largest individual and ≈1.0 for others; proportion dental vesicle/mucro ≈1.0 irrespective of body size. Mucro with basal dorsal denticle.

Remarks: The characters separating *S. bidentata* from *S. wolcotti* are discussed in the remarks to *S. wolcotti*. In chaetotaxy, *S. bidentata* is most similar to *S. thibaudi* **n. sp**., but differs in having only two prelabral setae, in the absence of peg-like smooth setae along head ventral groove, absence of macroseta 2 and presence of macroseta 7 on Th. 2 and the number of setae on the posterior face of the collophore. *Salina bidentata* apparently differs from *S. ventricolor* in chaetotaxy of Th. 2–Abd. 1, but see comments under *S. wolcotti*.

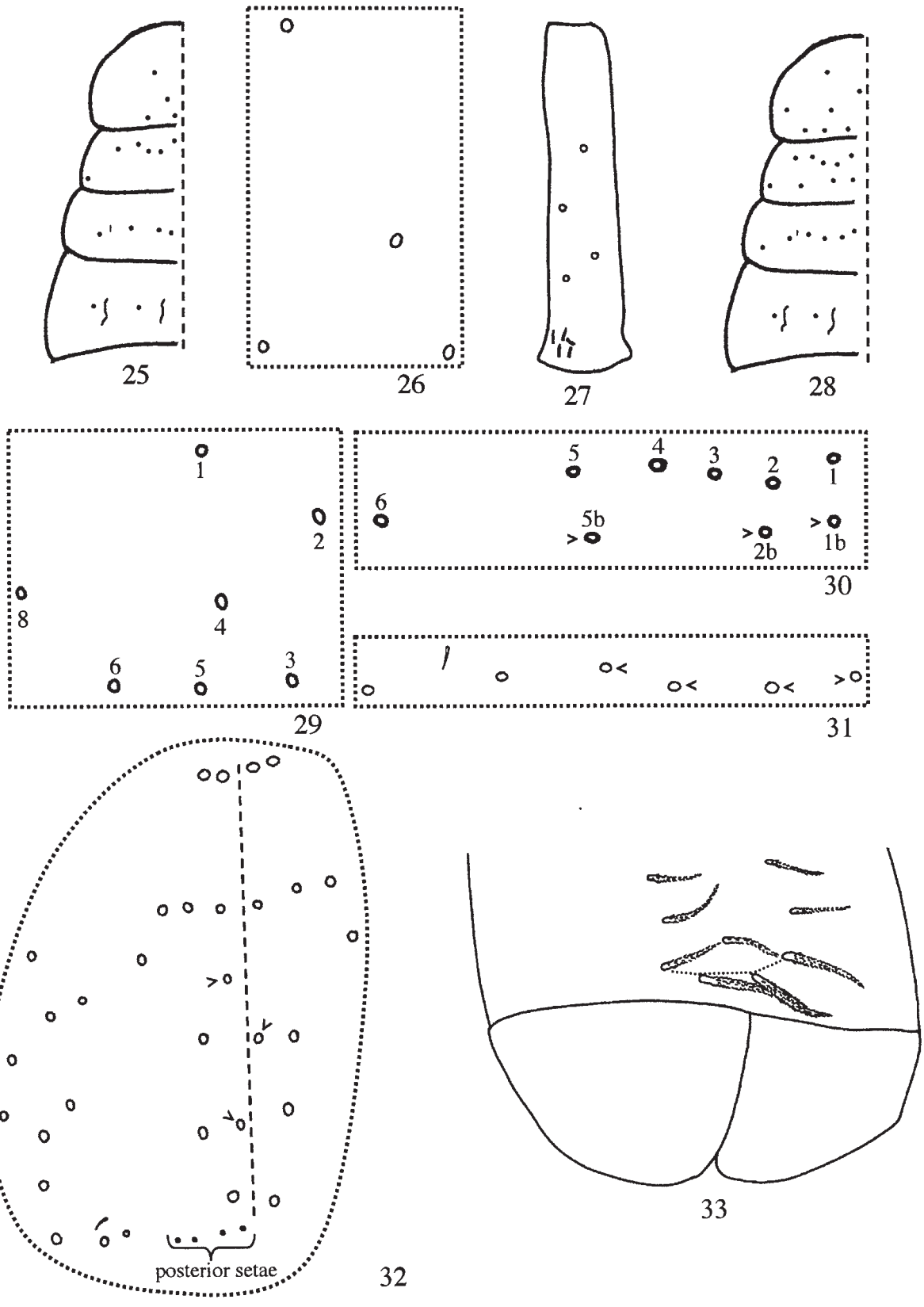
The individual from Buena Vista, Florida, is a small juvenile originally identified by Wray as *S. wolcotti* (the logical identification since Florida has more faunistic affinities with the Caribbean than with Central America). The specimen is partially folded over and most characters are difficult to see. The only unambiguous character distinguishing *wolcotti* and *bidentata*, the chaetotaxy of Th. 3, is clearly visible and this individual has 6 macrosetae arranged as in Figure 23, hence I have identified this specimen as *S. bidentata*. Hall (1988) reported *S. beta* from sugarcane in Florida, but the colour description is consistent with *S. bidentata*, not *S. beta*. It is likely that the species was identified using the key in Christiansen & Bellinger (1980), and the first couplet in the key separates species using the shape of the mucro.

Delamare-Deboutteville (1951a) reported *S. bidentata* from Ivory Coast, but the presence of this species in Africa seems doubtful. Two characters illustrated in Delamare-Deboutteville (1951a: p.69, Fig. 18) suggest the African species is different from *S. bidentata*: the very long antennae in the African specimen suggests it may belong in *Pseudosalina*, unfortunately, the mucro was not illustrated; in the African species Abd. 3 has

the paired bothriotricha in a posterior position whereas in *S. bidentata* (and in all other New World *Salina* for which this character has been illustrated) the paired bothriotricha are anterior (e.g., Mari Mutt 1987a, Fig. 28).



FIGURES 13–24. All figures show left aspect; arrowheads identify macrosetae absent or reduced in some individuals. 13–19. Chaetotaxy of *Salina wolcotti*; 13. Dorsal macrochaetotaxy of Ant. 1; 14. Schematic distribution of macrosetae on Th. 2–Abd. 2; 15. Th. 2; 16. Th. 3; 17. Abd. 1; 18. Abd. 2; 19. Latero-posterior view of collophore; 20–24, Chaetotaxy of *S. bidentata*; 20. Ant.1, dorsal view; 21. Schematic distribution of macrosetae on Th. 2–Abd. 2; 22. Th. 2; 23. Th. 3; 24. Abd. 1.



FIGURES 25–33. All figures show left aspect; arrowheads identify macrosetae absent or reduced in some individuals. 25–26 *Salina beta*; 25. Schematic distribution of macrosetae on Th. 2–Abd. 2; 26. Th. 2; 27–33 *S. thibaudi* **n. sp**.; 27. Ant. 1; 28. Schematic distribution of macrosetae on Th. 2–Abd. 2; 29. Th. 2; 30. Th. 3, setae 1b, 2b and 5b are absent in most individuals examined; 31. Abd. 1; 32. Abd. 4, circles are macrosetae, dots are posterior setae; 33. Posterior chaetotaxy of collophore.

Salina beta Christiansen and Bellinger, 1980

Salina beta Christiansen & Bellinger 1980: 1103, 1104, 1106, Fig. 819 (California, USA), original description and key. Yoshii 1983: 16, key, new species group. Hall 1988: 141, on sugarcane (Florida, USA), possibly a misidentification, see remarks under *S. bidentata*. Christiansen & Bellinger 1998: 1125, 1126, 1128, Fig. 819, key and description.

Material Examined: **USA**. California, Stanislaus Co., Modesto; lawn; 29 September 1961; H. Sinclair, coll. Holotype on one slide, California Department of Agriculture # 61J2–105, deposited at the California Academy of Sciences (entomology type # 15020).

Description: The following additions to the description of the species are based on the holotype. Length of holotype 1.1 mm. Colour pattern not seen but originally described as shown in Fig. 42. Ant. 1 with 2 dorsal macrosetae. Prelabral setae 2. Postlabial column CG obstructed, but apparently all setae ciliate. Tergal macrochaetotaxy of Th. 2–Abd. 2 as 4, 6, 4, 2 (Figs. 25–26): chaetotaxy of Th. 3 and Abd. 1 arranged as in *S. bidentata*. Abd. 4 with 4 posterior setae. Trochanteral organ with 13+14 setae. Unguis with only one distal unpaired tooth. Collophore anterior face with 3 macro- and 3 microsetae; lateral setae 15; posterior face with 1+1 setae. Proportions of dens/manubrium≈ 1, proportion dental vesicle/mucro ≈ 1. Mucro with basal dorsal denticle.

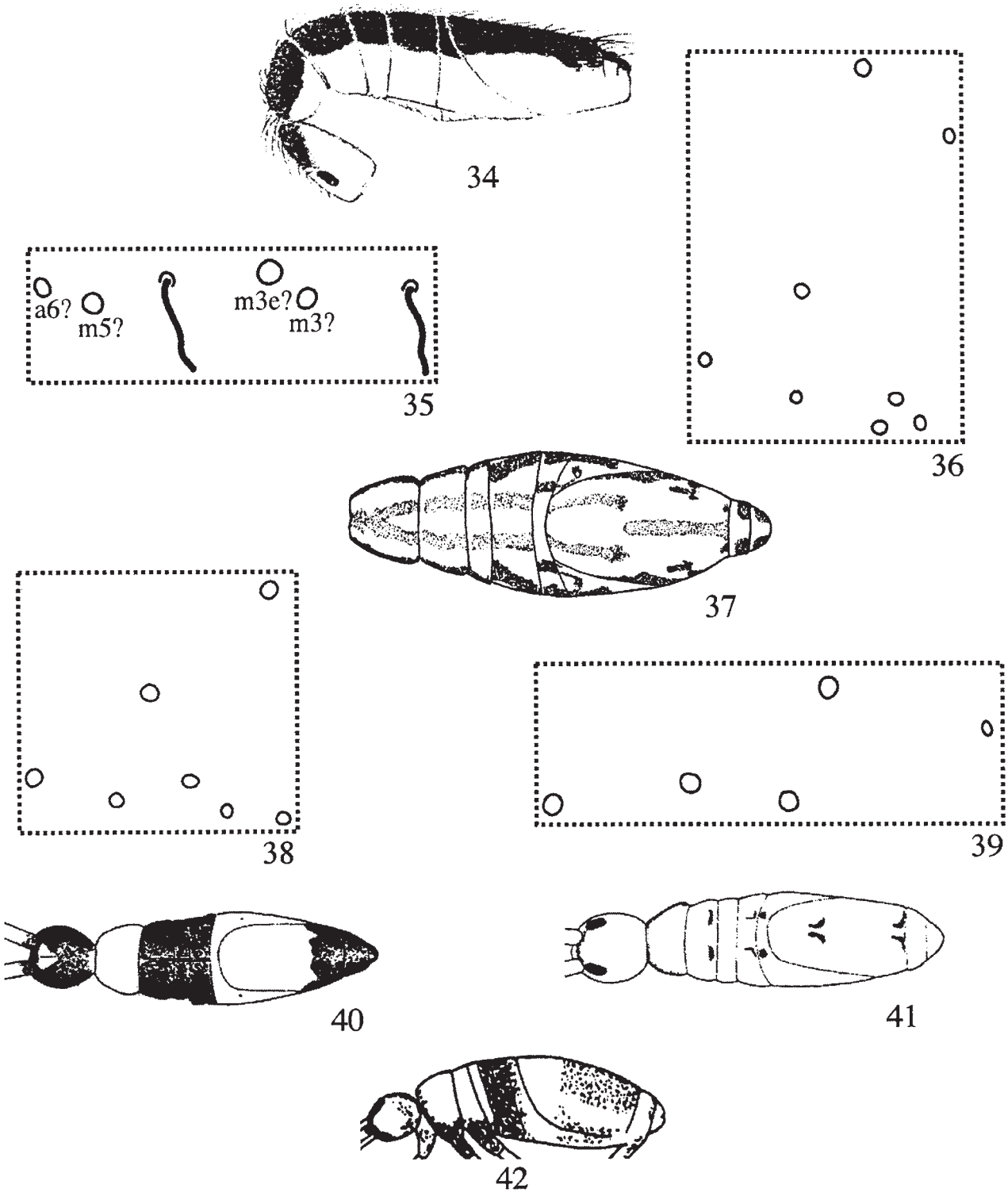
Remarks: *Salina beta* has a unique colour pattern that distinguishes it from all other New World species. In chaetotaxy *S. beta* is intermediate between *S. wolcotti*/*ventricolor* and *bidentata*/*thibaudi*, as shown in Table 1.

Salina thibaudi n. sp.

Material Examined: **Guadeloupe**. All collections by J.M. Thibaud, locality codes (e.g., G.#) as in Thibaud & Massoud (1979) and Massoud & Thibaud (1980)— Holotype, male G.194: near pond, south of Caraque, 5 km east of Point-a-Pitre, on coconut on the ground; 29 January 1980, slide mounted. Paratypes, all females. G.23: Boisvin-Masselas, 4 km west of Grands-Fonds, 60m elevation; meadow, under stone in dry pond; 9 March 1977; 1 slide-mounted juvenile. G.173: near Tombeau pond, 3 km north-northeast of Gosier; on coconut on the ground; 15 January 1980; 2 slide-mounted. G.195: close to pond southwest of Caraque; in mango tree litter; 29 January 1980; 1 slide-mounted. G.196: near pond at Boire, 1 km west of Cocoyer; leaf litter of breadfruit and flower of banana tree; 29 January 1980; 1 slide-mounted juvenile. **Costa Rica**. Cartago, El Salvador; 14 June 2004; C. Guillén, coll.; 1 slide-mounted.

Description: Length to 1.7 mm (smallest= 1.2 mm; average= 1.4 mm; n= 8). Background colour yellowish green, dorsal head pattern formed by narrow blue band along marginal circumference, wider near eyes and between antennae; mesothorax with a scatter of blue and narrow anterior and lateral stripe along margins; Th. 3–Abd. 5 with dark blue spots with irregular outer edges and unpigmented centres (i.e., Folsom's amoeboid spots, Fig. 12), corresponding to macrosetal insertions; ventral pattern formed by scattered light blue pigment on posterior two thirds of head, extending back in an irregular pattern through out all sterna, with higher density just posterior to metathoracic legs and on depression formed to accommodate furcula; antennae light blue, pigment forming rings distally on Ant. 1–3; femora with anterior blue longitudinal bands, one distal ring on femora, and one basal and one distal ring on tibiotarsi. Ant. 1 (Fig. 27) with 4 (3–5) dorsal macrosetae. Prelabral setae 4. Postlabial column CG with 9 setae (7–10), of which 3 (2–4) are short and smooth (Fig. 5). Macrochaetotaxy of Th. 2–Abd. 2 as 7(7–8), 6(5–9), 4(3–6), 2 (Figs. 28–31): Th. 2 with a supplementary macroseta posterior to seta number 3. One individual with 9 paired macrosetae on Abd. 4; 3 individuals with unpaired macrosetae inserted in differing patterns on each individual, but always in general area marked by arrow heads in Fig. 32. Abd. 4 with 4+4 (3–5, 1 individual with 7) posterior setae. Anterior face of collophore with 3 (4) distal macrosetae and 4 (3–6) microsetae, lateral setae 8–20, but region partially obscured in most individuals and actual number of setae difficult to ascertain (individual with 8 setae is 1.2 mm long, the smallest individual for which number of setae could be determined with confidence), posterior face of

collophore (Fig. 33) with 2+2 (1+1–4+4) short ciliate setae in row parallel to distal margin (joined by dotted lines in Fig. 33) and 1+1 (or 2+2) perpendicular to the distal margin. Proportion of dens/manubrium≈ 1.2; proportion of dental vesicle/mucro≈ 1. Mucro bidentate, most individuals with both teeth worn (1 individual with mucro appearing truncate).



FIGURES 34–42. All figures show left aspect. 34. *Salina trilobata* (after Schött 1896), 35. *S. mulcahyae*, Abd. 2; 36. *S. banski*, Th. 2; 37. *S. decorata* (after Mills 1932); 38. *S. tristani*, Th. 2; 39. *S. dedoris*/*hermana*, Th. 2; 40. *S. dedoris* (after Mari Mutt 1987a); 41. *S. hermana* (after Mari Mutt 1987a); 42. *S. beta* (after Christiansen & Bellinger 1980).

TABLE 1. Diagnostic table for the species of the genus *Salina* reported from the Americas.

Species (species group)[8]	Ant.1 M[1]	Pre-Lm setae[2]	Post Lb[3]	Th. 2 M	Th. 3 M	Abd. 1 M	Abd. 2 M	Abd. 4 posterior setae	Collophore posterior setae	Mucro shape	Unguiculus shape
beta USA[7] **(W)**	2	2	obscured	4	6	4	1,1	4	1	rectangular 3 teeth	truncate
bidentata CR, USA **(W)**	3 (2)[5]	2	5 (4)	6 (5–7) Fig. 15	6 Fig. 18	4 (2–4)	1,1	3	2+2	rectangular 2–3 teeth	truncate
thibaudi n. sp. CR, GUAD **(W)**	4	4	9 (7–10)	7 (8) Fig. 14	6 (5–9) Fig. 18	4 (3–6)	1,1	4 (3[6]–7)	3+3 (3–6); 1–3 unpaired	rectangular 2–3 teeth	truncate
ventricolor CUB **(W)**	?	?	?	5 Fig. 17	5 Fig. 21	3	1,1	?	?	rectangular 2–3 teeth	truncate
wolcotti PR **(W)**	2 (3)	2	5 (3–6)	3 (3–5) Fig. 16	4 (2–4) Fig. 20	2 (2–3)	1,1	3	1+1	rectangular 2–3 teeth	truncate
sp. A PAN **(W)**	3–4	4	7–8	6 Fig. 14	4 Fig. 19	2	2,1	2	2+2	rectangular 2 teeth	truncate
banski USA **(C)**	6	4	?	8	6	2	2,1	6	8+8	square 3 teeth	truncate
celebensis[4] ARG, BRA **(C)**	?	4	?	1	2	2	2,1	3?	8+8	square 3 teeth	truncate
decorata USA **(C)**	?	?	?	8	6	2	2,1	?	?	square 3 teeth	truncate
dedoris COL **(C)**	4	4	8–9	6	8	3	2,1	0	2+2; 0–1 unpaired	square 3–4 teeth	truncate
hermana COL **(C)**	4	4	8–9	6	8	3	2,1	0	2+2; 0–1 unpaired	square 3–4 teeth	truncate
panamae PAN **(C)**	?	?	?	1	3	2	2,1	?	?	square 3–4 teeth	truncate
trilobata MEX **(C)**	?	?	?	?	?	?	?	?	?	square 3 teeth	truncate
tristani CR, PR **(C)**	4	4	7 (6–8)	6–8	7 (6–10)	3 (2–6)	2,1	0	4+4 (5)	square 3–4 teeth	truncate
sp. B MEX **(C)**	3	4	7–8	3	5 (6)	2 (3)	2,1	0	1+1 (2)	square 3 teeth	truncate
sp. D USA **(C)**	6–7	4	5–6	12–15	7–8	4	2,1	5–6	6+6 (7); 1–2 unpaired	square 3 teeth	truncate
mulcahyae USA **(B)**	?	?	?	?	?	13	2,2	?	?	square 3 teeth	lanceolate
sp. C MEX **(B)**	7–6	4	8–12	≈35	21–24	8–9	2,2	11–13	Up to 40 total	square 3 teeth	truncate

(1) M= macrosetae. (2) Prelabral setae are ciliate in all species studied. (3) Setae along ventral groove. (4) Chaetotaxy from Yoshi 1981. (5) Parentheses show variation observed when more than 2 individuals were examined. (6) All individuals with 3 setae on one side of the body had 4 or more setae on the other side. (7) ARG=Argentina; BRA= Brazil; COL= Colombia; CR= Costa Rica; CUB= Cuba; GUAD= Guadeloupe; MEX= Mexico; PAN= Panama; PR= Puerto Rico; USA= United States. (8) Species groups: W= *beta*, C=*celebensis*; B= *borneensis*.

Remarks: *Salina thibaudi* **n. sp.** differs from all other species with bidentate mucro by the combined presence of 4 dorsal macrosetae on Ant. 1, 4 prelabral setae, 7 macrosetae on Th. 2, 6 on Th. 3, and at least 4 posterior setae on Abd. 4. Additional differences with other species are listed in Table 1.

Preliminary key to the named species of *Salina* reported from the Americas

1. Mucro short & square, with 3–4 teeth pointing posteriorly (Fig. 6–7) 2
1'. Mucro rectangular, narrow, with 2 largest teeth pointing dorsally (Fig. 8a) 9
2. Solid dorso-medial longitudinal band on head and trunk (Fig. 34); Mexico ..... *trilobata* (Schött)
2'. Without solid dorso-medial longitudinal band 3
3. Unguiculus lanceolate; Abd. 2 with 2 external macrosetae (Fig. 35); USA ..... *mulcahyae* Christiansen & Bellinger
3'. Unguiculus truncate; Abd. 2 with 1 external macroseta (Fig. 18) 4
4. Th. 2–Abd. 1 macroseta formula as 1,2,2; Argentina ..... *celebensis*[1] (Shäffer)
4'. Th. 2–Abd. 1 macroseta formula not 1,2,2 5
5. Th. 3–Abd. 1 with 3,1 macrosetae; Panama ..... *panamae* Jacquemart
5'. Th. 3–Abd. 1 number of macrosetae different from above 6
6. Abd. 4 with 6 posterior setae; Th. 2 with 8 macrosetae, 2 anterior & 6 posterior (Fig. 36); USA ..... *banski* MacGillivray/*decorata*[2] Mills
6'. Abd. 4 without posterior setae; Th. 2 with 5–8 macrosetae, 1 or no anterior & 5–7 posterior (Figs. 38–39) 7
7. Th. 2 with 1 anteromedial macroseta displaced anteriorly and clearly separated from posterior row (Fig. 38); Costa Rica, Puerto Rico ..... *tristani* Denis
7'. Th. 2 without anteromedial macrosetae, all medial macrosetae clearly close to posterior row (Fig. 39) 8
8. Head, Th. 2–Abd. 2 & Abd. 5 dark blue (Fig. 40); Colombia ..... *dedoris* Mari Mutt
8'. Head and abdomen greenish yellow (Fig. 41); Colombia ..... *hermana* Mari Mutt
9. Abd. 2 & 4 with dark & light blue transversal bands, respectively (Fig. 42); Th. 2 with 4 macrosetae arranged as in Figs. 25–26; USA (California, Texas) ..... *beta*
9'. Abd. 2 & 4 without transversal bands; Th. 2 with a different number of macrosetae[3] 10
10. Th. 2–Abd. 1 macroseta formula 4,5,3; Cuba ..... *ventricolor*
10'. Th. 2–Abd. 1 macroseta formula not 4,5,3 11
11. Prelabral setae 4; Ant. 1 with 4 dorsal macrosetae (Fig. 27); Abd. 4 with 4 or more posterior setae (Fig. 32); Posterior face of collophore with 3 or more setae (Fig. 33); Guadeloupe, Costa Rica ..... *thibaudi* **n. sp.**
11.' Prelabral setae 2; Ant. 1 with 2–3 dorsal macrosetae (Figs. 13, 20); Abd. 4 with 3 posterior setae (Fig. 9); posterior face of collophore with 1–2 paired setae (Fig. 19) 12
12. Chaetotaxy of Th. 2–3 as in Figs. 21–23; Posterior face of collophore with 2+2 setae; Costa Rica, Florida ..... *bidentata*
12'. Chaetotaxy of Th. 2–3 as in Figs. 14–16; Posterior face of collophore with 1+1 setae; Puerto Rico ..... *wolcotti*

1. Cassagnau (1963) identified material collected in Argentina and Brazil as *S. celebensis* based on chaetotaxy and colour pattern. However, the colour pattern figured does not match any of the forms of *S. celebensis* reported in the literature.

2. Although Christiansen & Bellinger (1998) indicate that *S. banski* and *S. decorata* cannot be distinguished based on chaetotaxy, the elaborate colour pattern of *S. decorata* (Fig. 35) makes separation of the forms possible. Further genetic work may be needed to arbitrate between the information content of chaetotaxy and colour pattern.

3. Some individuals of *S. wolcotti* may have 4 macrosetae, but the colour pattern and chaetotaxy of Th. 3 will distinguished them from *S. beta*.

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